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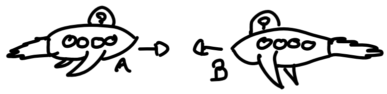
PHYS 230 HW 8



Problem 1

$V_A = V_B = (4/5)c$

A.) Sketch what ships look like RT A's Frame

$\sqrt{1 - v^2/c^2} = \sqrt{1-(4/5)^2} = (3/5)$

$D_{B_R} = 450 m$
$D_{A_R} = 150 m$

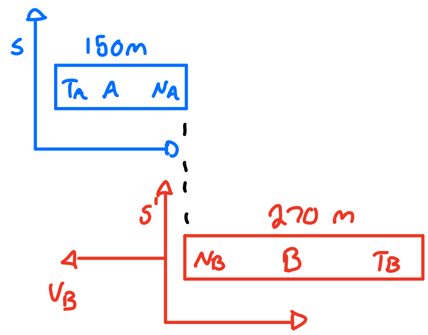
B will contract in length

$d_B = D_{B_R} \cdot \sqrt{1 - v^2/c^2} = 450m(3/5) = 270 m$
$d_B = 270 m$

To A's RF

0.5 cm = 50 m

S - SS A Frame
S' - SS B Frame



A will see . . .

$D_A = 150 m$
$D_B = 270 m$

B.) What do all the clocks read? RT A.

$T_A = N_A = 0$ Because A is not moving and all clocks are synchronized.

$N_A = N_B$ Because both clocks are synchronized when origins pass.

But since B is moving, its nose clock will lag and the tail clock will be ahead.

$\Delta t = \frac{vx}{c^2} = \frac{(4/5)c(450)m}{c^2} = 360 \ m/c$

$v = (4/5)c$
$x = (450)m$

$$\boxed{\begin{matrix} T_A = 0 \ m/c & N_A = 0 \ m/c \\ T_B = 360 \ m/c & N_B = 0 \ m/c \end{matrix}}$$

C.) Time for tail of B to reach nose of A? RT A.

Values RT A

$D_B = 270 m$
$V_B = (4/5)c$

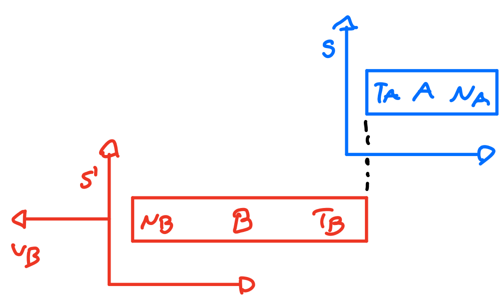
$\Delta t = \frac{D}{v} \therefore \Delta t = \frac{270m}{(4/5)c} = 270m \cdot \frac{5}{4c} = \frac{1350}{4} = \frac{675}{2} m/c$

$$\Delta t = \frac{675}{2} m/c$$

D.) Sketch when tail of B is at nose of A, RT A

0.5 cm = 50 m

S - SS A Frame
S' - SS B Frame



E.) What are the clock readings in part D? RT A

T_A and N_A will tick by at same rate
$T_A = N_A = \left(\frac{625}{2}\right) m/c$

B is moving so it's clocks will be out of sync with A.

$\sigma = \sqrt{1 - v^2/c^2}$
$\sigma = (3/5)c$

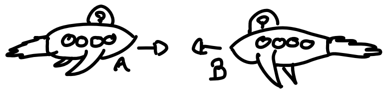
$\Delta t = \frac{\Delta t'}{\sigma}$ $\quad$ $\Delta t' = \Delta t \sigma$

$\Delta t' = \left(\frac{675}{2}\right) m/c \left(3/5\right) = \frac{405}{2} m/c \equiv N_B$

$T_B = N_B + (360 \, m/c) = \frac{1125}{2} m/c \equiv T_B$

$T_A = \left(\frac{675}{2}\right) m/c \quad N_A = \left(\frac{675}{2}\right) m/c$
$T_B = \left(\frac{1125}{2}\right) m/c \quad N_B = \left(\frac{405}{2}\right) m/c$

Problem 2 $V_A \wedge V_B = (4/5)c$



A.) Sketch when noses meet RT B.

$$\sigma \equiv \sqrt{1 - v^2/c^2} = \sqrt{1-(4/5)^2} = 3/5$$
$$\sigma = (3/5)$$

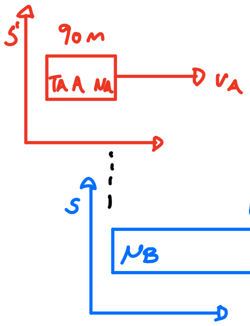
$D_{AR} = 150m$
$D_{BR} = 450m$

From B's perspective A will shrink.
$d = D\sigma$
$d = 150m(3/5) = 90m$

B will see
$D_A = 90m$
$D_B = 450m$

0.5 cm = 50 m

S - SS B
S' - SS A



B.) What are the clock readings when noses meet? RT B.

On B
$N_B \wedge T_B$ are synced since not moving.
$\therefore N_B = T_B = 0$

On A
N_A is set to zero when noses' meet.
T_A will be ahead of the lagging N_A clock.
$\therefore N_A = 0 \wedge T_A = \frac{vx}{c^2}$

$$T_A = \frac{vx}{c^2} = \frac{(4/5)c(150)m}{c^2} = 120\ m/c$$

$v = (4/5)c$
$x = 150\ m$

$$\boxed{\begin{array}{ll} T_A = 120\ m/c & N_A = 0\ m/c \\ T_B = 0\ m/c & N_B = 0\ m/c \end{array}}$$

C.) How long does it take for nose of A to reach tail of B?

B will see
$D = 450m$
$V = (4/5)c$

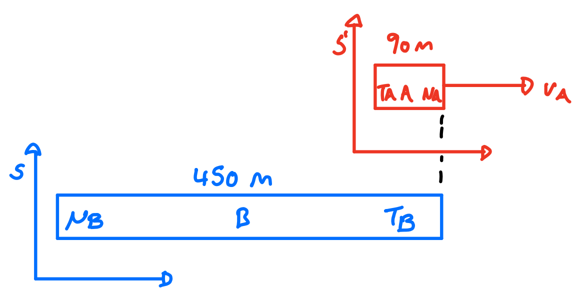
$$\Delta t = \frac{D}{V} \quad \therefore \quad \Delta t = \frac{450m}{(4/5)c} = \frac{1125}{2}\ m/c$$

$$\boxed{\Delta t = \frac{1125}{2}\ m/c}$$

D.) Sketch when A reaches tail of B. RT B

0.5 cm = 50 m

S - SS B
S' - SS A



E.) What are the clock readings found in part D? RT B

For B

Their clocks will tick at same rate and be synchronized.

$\therefore\ N_B = T_B = \frac{1125}{2}\ m/c$

$$\boxed{\begin{array}{ll} T_A = \left(\frac{915}{2}\right) m/c & N_A = \left(\frac{675}{2}\right) m/c \\ T_B = \left(\frac{1125}{2}\right) m/c & N_B = \left(\frac{1125}{2}\right) m/c \end{array}}$$

For A

The nose clock will lag the tail

$$\Delta t = \frac{\Delta t'}{\sigma} \qquad \sigma = \sqrt{1 - v^2/c^2} = (3/5)$$

$$\Delta t' = \Delta t \cdot \sigma = \left(\frac{1125}{2}\right) m/c\,(3/5) = \frac{675}{2}\ m/c$$

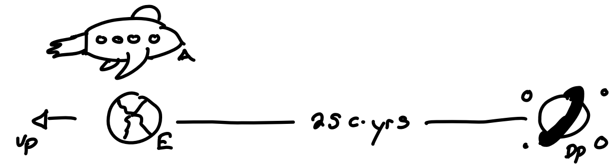
$$\therefore\ N_A = \frac{675}{2}\ m/c$$

$$\therefore\ T_A = N_A + 120\ m/c$$

$$T_A = \frac{675}{2}\ m/c + 120\ m/c = \frac{915}{2}\ m/c$$

Problem 3

RT SS A @ rest $V_p = (5/13)c$

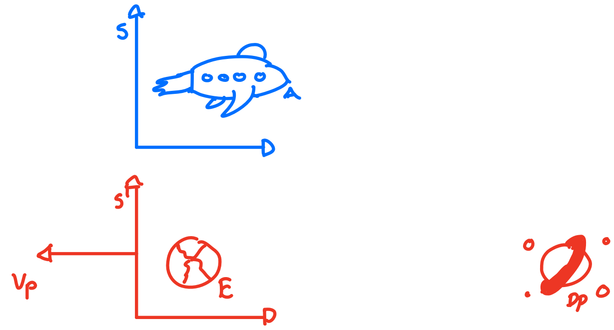


A.) Sketch 3 events.

S - SS A
S' - E & DP

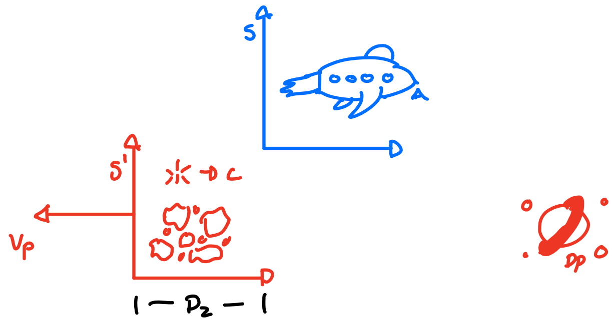
E_1

Earth departs.



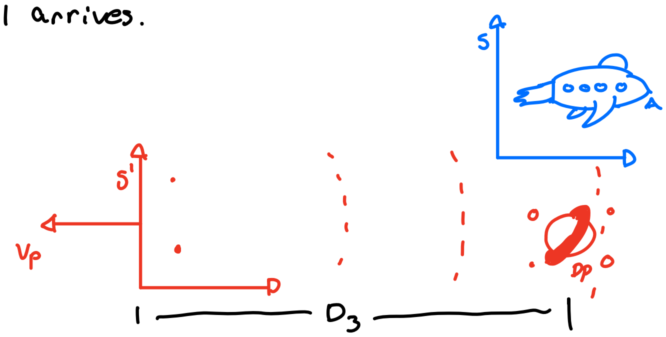
E_2

Earth explodes.



E_3

Signal arrives.



$D_3 = v \cdot t_3 \quad D_3 = c(t_3 - t_2)$

B.) Distance of planets RT SS ?

$\sigma \equiv \sqrt{1 - v^2/c^2}$ $\quad D = 25\ c \cdot yrs$

$d = D\sigma$ $\quad \sigma = \sqrt{1 - v^2/c^2} = \sqrt{1 - (5/13)^2} = (12/13)$

$\sigma = (12/13)$

$d = 25\ c \cdot yrs\,(12/13) = 23\ c \cdot yrs$

$D_{ss} = 23\ c \cdot yrs$

C.) When distant planet arrives, what time does SS read?

RT SS

$D = 23\ c \cdot yrs$

$v = (5/13)c$

$\Delta t = \dfrac{D}{v} \quad \therefore \quad \Delta t = \dfrac{23\ c \cdot yrs}{(5/13)c} = 60\ yrs$

$\Delta t_{ss} = 60\ yrs$

D.) When distant planet arrives, what does Earth clock read?

$\sigma = \sqrt{1 - v^2/c^2}$

$\Delta t = \dfrac{\Delta t'}{\sigma}$ $\quad \therefore \quad \Delta t' = \sigma \Delta t = 60 \text{yrs} (12/13) = 55 \text{ yrs}$

$\Delta t = 60 \text{ yrs}$

$\sigma = (12/13)$

$\Delta t'_E = 55 \text{ yrs}$

E.) When distant planet arrives, what does distant planet read?

Dp originally off by $\dfrac{vx}{c^2}$

$v = (5/13)c \quad x = 25 \text{ c·yrs}$

$t_{D_i} = \dfrac{(5/13)c(25 \text{ c·yrs})}{c^2} = 9.6 \text{ yrs}$

$t_{pp} = \Delta t_E + 9.6 \text{ yrs}$

$= 55 \text{ yrs} + 9.6 \text{ yrs}$

$t_{pp} = 65 \text{ yrs}$

$\Delta t_{pp} = 65 \text{ yrs}$

F.) When signal is sent, what does ship clock read?

Notice for distances...

$D_3 = v \cdot t_3 \quad D_3 = c(t_3 - t_2)$

$vt_3 = c(t_3 - t_2)$

$vt_3 = ct_3 - ct_2$

$ct_2 = ct_3 - vt_3$

$t_2 = t_3 - \dfrac{v}{c} t_3$

$t_2 = t_3 (1 - v/c)$

$t_2 = t_3 (1 - v/c)$

$t_2 = (60 \text{yrs})(1 - (5/13))$

$t_2 = 36.9 \text{ yrs}$

$\Delta t_{ss} = 37 \text{ yrs}$

G.) When signal is sent, what does Earth clock read?

$\sigma = \sqrt{1 - v^2/c^2} = 12/13$

$\Delta t = \dfrac{\Delta t'}{\sigma}$ $\quad \therefore \quad \Delta t' = \Delta t \sigma = 37 \text{ yrs} (12/13) = 34.1 \text{ yrs}$

$\Delta t = 37 \text{ yrs}$

$\Delta t_E = 34 \text{ yrs}$

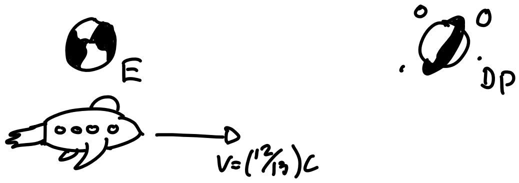
H.) When signal is sent, what does distant planet clock read?

Dp originally off by 9.6 yrs

$\therefore \quad \Delta t_{pp} = \Delta t_E + 9.6 \text{ yrs} = 34 \text{ yrs} + 9.6 \text{ yrs} = 43.6 \text{ yrs}$

$\Delta t_{pp} = 44 \text{ yrs}$

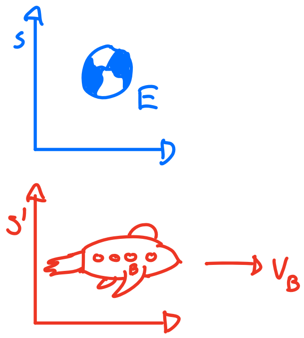
Problem 41



A.) Sketch diagrams from Alberts frame.

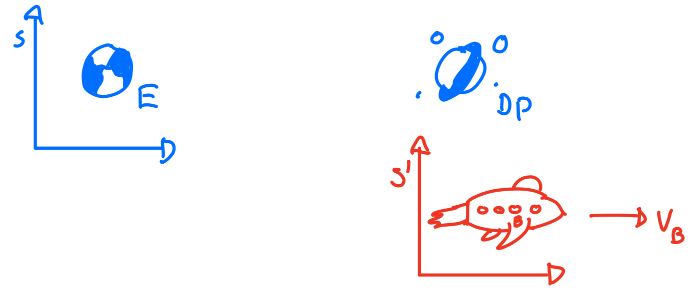
S- Albert and Dp
S'- Billy and SS

E_1
Billy leaves Albert



E_2
Billy arrives at Dp

Billy measures $\Delta x' = 0$



B.) How old was Albert?

$$\sigma \equiv \sqrt{1 - v^2/c^2} \qquad \sigma = (5/13)$$

$$\Delta t = \frac{\Delta t'}{\sigma} \qquad \Delta t' = 25 \text{ c·yrs}$$

$$\Delta t = \frac{25 \text{ c·yrs}}{(5/13)} = 65 \text{ yrs}$$

$$\Delta t_A = 65 \text{ yrs}$$

C.) According to Albert what is the distance to Dp?

Acc. To Albert

$v = (12/13)c$
$\Delta t = (65)$yrs

$$D = v \cdot \Delta t = \left(\frac{12}{13}\right)c\left(65 \text{ yrs}\right) = \frac{60 \text{ c·yrs}}{2} = 30 \text{ c·yrs}$$

$$D_A = 30 \text{ c·yrs}$$

D.) According to Billy what is the distance to Dp?

Acc. To Billy

$V = (12/13)c$
$\Delta t = (25)$yrs

$$D = v \cdot \Delta t = \left(\frac{12}{13}\right)c\left(25\right)\text{yrs} = \frac{300}{13} = \frac{150}{13} \text{ c·yrs}$$

$$\boxed{D = \frac{150}{13} \text{ c·yrs}}$$

E.) When Billy reaches Dp, what do clocks read?

RT E and Dp

Clocks are synched will tick at same rate

$t_E \wedge t_{Dp} = \frac{65}{2}$ yrs

$\Delta t_E = 65/2$ yrs

$\Delta t_{Dp} = 65/2$ yrs

RT Billy

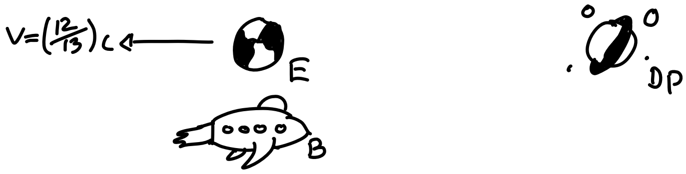
He sees his time as

$\Delta t_B = \frac{150}{13}$ yrs

$\Delta t_E = 65/2$ yrs $\Delta t_{Dp} = 65/2$ yrs

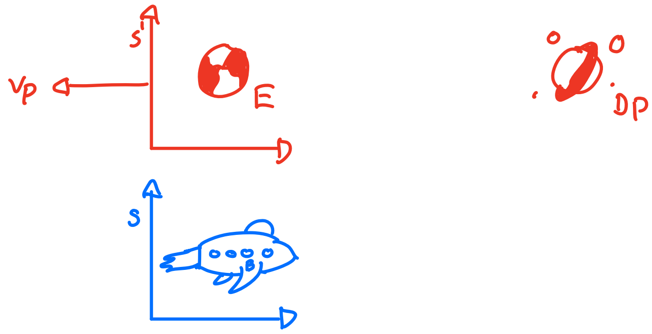
$\Delta t_B = \frac{150}{13}$ yrs

Problem 5



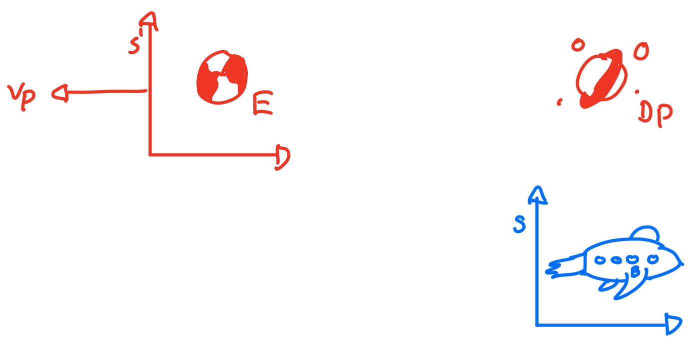
A.) Sketch two events from rest frame of Billy.

$\underline{E_1}$
Earth departs Billy



S – Billy and SS
S' – Earth Dp

$\underline{E_2}$
Dp arrives at Billy



B.) What are the clock readings when Earth leaves?

Billy and Albert synched clocks originally
$\therefore \; t_B \wedge t_E = 0$ yrs

$$\boxed{t_B = 0 \text{ yrs} \quad t_E = 0 \text{ yrs} \quad t_{DP} = \frac{360}{13} \text{ yrs}}$$

DP will be ahead by $\frac{vx}{c^2}$

$v = (12/13)c$

$x = 30$ c·yrs

$$\frac{(12/13)c(30)\text{ yrs}}{c^2} = \frac{360}{13} \text{ yrs}$$

C.) What are the clock readings when Dp arrives?
$\sigma = (5/13)$

$\underline{\text{RT Billy}}$

$d = D\sigma = 30 \text{ yrs}(5/13)c = \frac{150}{13} \text{ cyrs}$

$v = (12/13) \quad \Delta t = \frac{D}{V} = \frac{(\frac{150}{13})c\cdot\text{yrs}}{(12/13)c} = \frac{150}{12} \text{ yrs}$

$\Delta t_B = \frac{150}{12}$ yrs

$\underline{\text{RT Planets}}$

$\Delta t_E = \Delta t\,\sigma = \left(\frac{150}{12}\right)\text{yrs}\left(\frac{5}{13}\right) = \frac{125}{26}$

$\Delta t_{DP} = \Delta t_E + \frac{360}{13} = \frac{65}{2} \text{ yrs}$

$\Delta t_{DP} = \frac{65}{2}$ yrs

$$\boxed{\Delta t_B = \frac{150}{12} \text{ yrs} \quad \Delta t_{DP} = \frac{65}{2} \text{ yrs} \quad \Delta t_E = \frac{125}{26} \text{ yrs}}$$